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PATENT APPLICATION

for

METHOD OF PRODUCING A PLATE SPRING

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METHOD OF PRODUCING A PLATE SPRING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a method for producing a plate spring.

5 2. Background Information

Plate springs are conventionally employed in automobile components. An example of this type of plate spring is a diaphragm spring employed in a clutch cover assembly of a clutch device for use in an automobile. The diaphragm spring is a disk-shaped member that is used in the clutch cover assembly, and is comprised of an
10 annular resilient portion and a plurality of levers that extend inward in the radial direction from the resilient portion. Either the inner or outer periphery of the annular resilient portion is supported by the clutch cover, and the periphery not supported thereby biases a pressure plate. A release mechanism that includes a bearing and the like engages with the tips of the plurality of the levers.

15 With this type of diaphragm spring, plastic working such as shot-peening is typically performed on either both sides or one side of the resilient portion in order to increase the fatigue strength thereof. For example, when shot-peening is performed, small particles strike the surface of the diaphragm spring at high speed, thereby plastic working only the surface layer of the diaphragm spring. When this type of shot-
20 peening is performed, the surface layer microscopically expands due to the large number of shots. However, because the surface layer cannot be extended due to the resistance from the inner surface layer, the result is that the shot-peening produces large compression residual stress in the surface layer, and the fatigue strength at that location increases thereby. Thus, the durability of the diaphragm spring will increase.

25 In addition, because the diaphragm spring has an impact on the operational feel and the torque capacity of the clutch of the clutch device, the ratio between the height H in the axial direction and the thickness t (hereinafter H/t) of the resilient portion of the diaphragm spring will be modified in order to obtain the desired load – displacement characteristics.

30 However, when only the H/t of the resilient portion of the diaphragm spring is changed, it may be impossible to design a clutch device having the desired load – displacement characteristics because of restrictions on the dimensions thereof. In addition, the range in which the H/t can be changed is limited because insufficient

strength may be produced in the inner and/or outer peripheries of the resilient portion due to the change in the H/t thereof. Thus, it is preferable to have a method of making the load - displacement characteristics adjustable without changing the H/t of the resilient portion. This is needed not only for a diaphragm spring, but also a plate
5 spring such as a cone spring or the like that is employed in a multi-disk clutch of a transmission device.

In view of the above, there exists a need for a method of producing a plate spring which overcomes the above mentioned problems in the prior art. This invention addresses this need in the prior art as well as other needs, which will
10 become apparent to those skilled in the art from this disclosure.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method which can adjust the load - displacement characteristics of a plate spring to a desired degree.

According to one aspect of the present invention, a method of producing a
15 plate spring comprises the steps of preparing a plate spring that includes an annular resilient portion, and applying compression residual stress to a portion of the resilient portion.

Normally, the load - displacement characteristics of the resilient portion of the plate spring generally exhibit non-linear characteristics such that the displacement
20 increases in proportion to the load, the load then decreases from a certain displacement to an increased displacement (high load peak), and then the load again increases from that increased displacement. This qualitative trend is identical regardless of whether compression residual stress is applied to the entire surface of both sides or the entire surface of one side of the resilient portion in order to increase
25 the fatigue strength thereof.

However, as a result of intensive research, the present inventors have discovered that by applying compression residual stress to only a portion of the resilient portion, the load - displacement characteristics of the resilient portion will change, and this quality can be used as a method of obtaining the desired load -
30 displacement characteristics in the resilient portion without changing the H/t of thereof. Thus, the degree of freedom one has in the design of a plate spring can be increased.

According to another aspect of the present invention, shot-peening is performed in order to apply compression residual stress.

In this aspect of the present invention, residual stress can be easily applied to predetermined portions of the resilient portion because shot-peening is performed.

5 According to another aspect of the present invention, compression residual stress is applied to at least one surface of the resilient portion.

In this aspect of the present invention, the difference between the high peak load and the low peak load of the resilient member changes compared to when compression residual stress is not applied thereto. For example, when this method is
10 applied to a diaphragm spring employed in a clutch device, the size of the friction pads of the clutch disk that forms the clutch device can be enlarged because the displacement range of the disengagement stroke of the clutch is widened.

According to another aspect of the present invention, a method of producing a plate spring comprises the steps of preparing a plate spring that includes an annular
15 resilient portion, applying a first compression residual stress to the entire resilient portion, and then applying a higher second compression residual stress to a portion of the resilient portion.

In this method of producing a plate spring, compression residual stress is applied to the entire resilient portion in a first residual stress application step to
20 increase the durability thereof, and a higher compression residual stress is applied to a portion of the resilient portion in a second residual stress application step so that the load - displacement characteristics of the resilient portion can be modified. Thus, the degree of freedom one has in the design of a plate spring can be increased.

These and other objects, features, aspects and advantages of the present
25 invention will become apparent to those skilled in the art from the following detailed description, which, taken in conjunction with the annexed drawings, discloses a preferred embodiment of the present invention.

BRIEF DESCRIPTION OF THE DRAWINGS

Referring now to the attached drawings which form a part of this original
30 disclosure:

Fig. 1 shows cross-sectional view of a clutch device having a diaphragm spring produced by a method of producing a plate spring according to the present invention;

Fig. 2 shows a partial plan view of the diaphragm spring of Fig. 1 which depicts locations thereon where compression residual stress can be applied;

Fig. 3 shows a partial plan view of the diaphragm spring of Fig. 1 which depicts other locations thereon where compression residual stress can be applied;

5 Fig. 4 shows a partial plan view of the diaphragm spring of Fig. 1 which depicts other locations thereon where compression residual stress can be applied;

Fig. 5 shows a partial plan view of the diaphragm spring of Fig. 1 which depicts other locations thereon where compression residual stress can be applied;

10 Fig. 6 shows a partial plan view of the diaphragm spring of Fig. 1 which depicts other locations thereon where compression residual stress can be applied;

Fig. 7 shows a partial plan view of the diaphragm spring of Fig. 1 which depicts other locations thereon where compression residual stress can be applied;

Fig. 8 shows a partial cross-sectional view of the diaphragm spring of Fig. 1; and

15 Fig. 9 shows a graph depicting the load - displacement characteristics of a diaphragm spring produced by a conventional method and a diaphragm spring produced by the method of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

(1) Construction of the clutch device

20 The clutch device shown in Fig. 1 is a device for transmitting and interrupting engine torque from a flywheel 2 to a transmission (not shown in the figures). O-O in Fig. 1 represents the rotation axis of the clutch device 1.

25 The flywheel 2 is a disk-shaped member, and the inner peripheral portion thereof is fixed to the distal end of a crankshaft with a plurality of bolts (not shown in the figures). In addition, an annular and flat friction surface 2a that faces the transmission side in the axial direction (the right side in Fig. 1) is formed on the outer periphery of the flywheel 2.

The clutch device 1 is mainly comprised of a clutch disk assembly 6, a clutch cover assembly 7, and a release mechanism (not shown in the figures).

30 The clutch disk assembly 6 is comprised of a frictional coupling portion 61 that is comprised of friction facings and the like that are disposed on the outer peripheral sides thereof, a damper mechanism 62 that is comprised of a clutch plate that is fixed to the frictional coupling portion 61, a retaining plate, a coil spring, and

the like, and a hub flange 63 that is coupled to the damper mechanism 62. The frictional coupling portion 61 is disposed opposite the friction surface 2a of the flywheel 2. The inner periphery of the hub flange 63 is spline-engaged with a transmission shaft (not shown in the figures) such that it rotates integrally therewith.

5 The clutch cover assembly 7 is mounted to the flywheel 2, and is a mechanism for pressing the frictional coupling portion 61 of the clutch disk assembly 6 to the flywheel 2 and releasing the same therefrom. The clutch cover assembly 7 is mainly comprised of a clutch cover 71, a pressure plate 72, a diaphragm spring 73, and two wire rings 75 that are supported by tabs 71a that are bent from the inner periphery of
10 the clutch cover 71 and which support the diaphragm spring 73. The clutch cover 71 is plate shaped, and has a large diameter hole formed in the center thereof. The outer peripheral end of the clutch cover 71 is fixed to the outer peripheral end of the flywheel 2 by means of a plurality of bolts 74. The pressure plate 72 is an annular member that is disposed inside the clutch cover 71, and serves to maintain the friction
15 coupling portion 61 of the clutch disk assembly 6 between it and the friction surface 2a of the flywheel 2.

 As can be clearly seen in Fig. 2, the diaphragm spring 73 is comprised of an annular resilient portion 73a, and a plurality of levers 73b that extend from the resilient portion 73a in the radial direction. A slit 73c is formed in between adjacent
20 levers 73b, and a small diameter hole 73d is formed in the base end of each slit 73c. The tabs 71a of the clutch cover 71 shown in Fig. 1 pass through several of the small diameter holes 73d, and are bent outward in the radial direction. Referring now to Fig. 9, the two wire rings 75 have an inner peripheral portion 83 of the resilient portion 73a interposed therebetween in the axial direction. An outer peripheral portion 82 of
25 the resilient portion 73a is in contact with the pressure plate 72. A release mechanism not shown in the figures engages with the tips of the levers 73b of the diaphragm spring 73, e.g., the peripheral area around a central hole 73e.

(2) Method of producing the diaphragm spring

 The process by which the diaphragm spring 73 is produced will now be
30 described. First, a disk-shaped plate member is obtained by stamping the same from a steel plate. Next, the slits 73c, the small diameter holes 73d, and the central hole 73e are stamped therefrom.

The flat diaphragm spring 73 is then formed into a cone shape as shown in Fig. 8, and is subject to shot-peening after being heat treated. This shot-peening is performed on any surface of the diaphragm spring 73 that retains a flat cone shape in the free state.

5 Note that the shot-peening is not performed on the entire surface of the diaphragm spring 73, but as shown in Figs. 2 to 7, is only performed on a portion of the resilient portion 73a. The positions that are shot-peened may include the inner peripheral side, the outer peripheral side, or the central portion of the resilient portion 73a, and may be annular in shape or localized (refer to the hatched portions in each
10 figure).

More specifically, it is preferable that compression residual stress is applied by means of shot-peening to between about 5% and about 95% of the surface area of the resilient portion 73a. In addition, the depth in the thickness direction of the surface in which compression residual stress is applied by means of shot-peening is preferably
15 set to be within about 20% of the plate thickness t of the resilient portion 73a. Furthermore, the size of the compression residual stress to be applied is preferably set to be from about 200 MPa to about 1500 MPa. Note that the compression residual stress may be locally applied by means of a method other than shot-peening. However, it is thought that the shot-peening method described in the present
20 embodiment is a superior way of locally applying compression residual stress.

As shown in Fig. 9, compared to situations in which no shot-peening is performed, performing shot-peening in the manner described above will change the difference between the high load peak and the low load peak of the load - displacement characteristics of the resilient portion 73a of the diaphragm spring 73,
25 and will widen the flat region near the high load peak thereof. In other words, a diaphragm spring 73 can be obtained in which a displacement range $L1$ of the resilient portion 73a thereof is wider than a displacement range L of a resilient portion of a conventional diaphragm spring. Thus, it is possible to increase the size of the friction pads of the clutch plate that forms the clutch disk assembly 6 because the
30 disengagement stroke of the clutch device 1 can be enlarged.

(3) Experimental example in which compression residual stress is applied

Fig. 9 will be used below to explain the change in the load - displacement characteristics when compression residual stress is applied to a portion of the resilient portion 73a of the diaphragm spring 73.

First, when compression residual stress is applied in a conventional manner to the entire surface of a concave surface 80 on the resilient portion 73a, the size of the load will be different than when shot-peening is not performed. However, the qualitative trend of the load - displacement will be the same, and a widening of the flat portion near the high load peak shown in Fig. 9 will not be seen. Thus conventionally, an increase in the durability of the resilient portion 73a is possible even if compression residual stress is applied by shot-peening, but changing the load - displacement characteristics thereof was thought to be difficult.

However, as noted above, it is now understood that when shot-peening is performed on only a portion of any surface, the difference between the high load peak and the low load peak will change, and a displacement range that is wider than that when shot-peening is not performed can be obtained.

As a result of studying the aforementioned experimental results, the present inventors discovered that the load - displacement characteristics of the resilient portion 73a of the diaphragm spring can be adjusted by applying compression residual stress to a portion of the resilient portion 73a of the diaphragm spring 73.

This method of adjusting the load - displacement characteristics of the resilient member 73a of the diaphragm spring 73 not only has the effect of widening the flat region near the high load peak as noted above, but also can obtain the following effects.

1. For example, it may become necessary to modify the ratio of the height H in the axial direction of the resilient portion 73a of the diaphragm spring 73 to the plate thickness t thereof (H/t) when the space in which the diaphragm spring 73 can be installed is limited. However, even in this situation, the change in the load - displacement characteristics of the resilient portion 73a due to the change in H/t can be compensated for by applying compression residual stress to a portion of the resilient portion 73a, and thus the load - displacement characteristics of the resilient portion 73a can be maintained.

2. In addition, the grade of the materials used for the diaphragm spring 73 can be reduced because both a change in the load - displacement characteristics of the

resilient portion 73a and an increase in the durability thereof can be obtained by applying compression residual stress thereto. Thus, it is possible to increase the degree of freedom one has in the design of the diaphragm spring 73.

(4) Other embodiments

5 1. In the aforementioned embodiment, the method of producing the plate spring of the present invention was applied to a diaphragm spring. However, this method can also be applied to a plate spring such as a cone spring or the like that is employed in a multi-disk clutch of a transmission device.

 2. In the aforementioned embodiment, compression residual stress was
10 applied to only a portion of the resilient portion. However, the plate spring may be produced by applying compression residual stress to the entire resilient portion in order to increase durability (first residual stress application step), and then applying a high residual stress to a portion of the resilient portion (second residual stress application step). Even in this situation, the load - displacement characteristics can be
15 changed in the same way as that of the aforementioned embodiment because the compression residual stress applied to a portion of the resilient portion is relatively higher than that applied to another portion thereof.

 Any terms of degree used herein, such as “substantially”, “about” and “approximately”, mean a reasonable amount of deviation of the modified term such
20 that the end result is not significantly changed. These terms should be construed as including a deviation of at least $\pm 5\%$ of the modified term if this deviation would not negate the meaning of the word it modifies.

 This application claims priority to Japanese Patent Application No. 2002-212362. The entire disclosure of Japanese Patent Application No. 2002-212362 is
25 hereby incorporated herein by reference.

 While only selected embodiments have been chosen to illustrate the present invention, it will be apparent to those skilled in the art from this disclosure that various changes and modifications can be made herein without departing from the scope of the invention as defined in the appended claims. Furthermore, the foregoing
30 description of the embodiments according to the present invention are provided for illustration only, and not for the purpose of limiting the invention as defined by the appended claims and their equivalents.